

Extraction of jet topology using three particle correlations

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Abstract

Recent theoretical studies have indicated that the topological features of away-side jet fragments can be significantly altered by medium-induced modifications. The leading candidates resulting from such modifications are Mach Cones and deflected jets. We show that three particle correlations are able to distinguish between these different modification scenarios. Initial results from an application of the method to Au+Au collisions at RHIC ($\sqrt{s_{NN}} = 200$ GeV) are presented.

Key words:

PACS:

1 Introduction

It is now generally accepted that in Au+Au collisions at RHIC, a state of matter characterized as a strongly interacting, low viscosity fluid of quarks and gluons (termed sQGP) is created. In addition to the soft processes leading to the formation of this medium, there are relatively rare hard parton-parton collisions. The scattered partons may interact with the medium as they propagate through it, till they finally fragment into jet-like clusters. Since such interactions can modify jet fragmentation, jets provide a powerful probe of the medium, provided one can reliably extract the jet signal from the relatively large background which exists in RHIC collisions. Jet modification leading to shock wave induced conical flow (a “sonic boom”) [1] and a “deflected-jet” induced by interactions between the propagating partons and the flowing medium [2] are leading candidates.

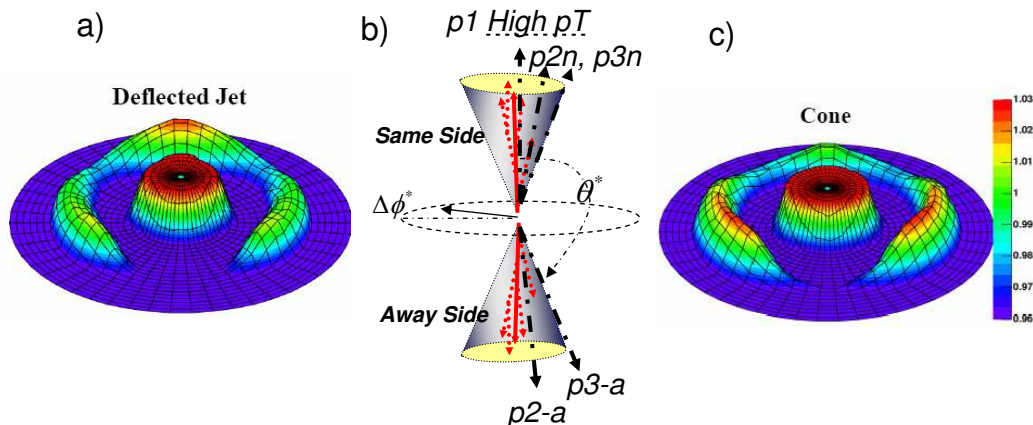


Fig. 1. (middle panel) Schematic illustration of the coordinate system used for the three-particle correlation analysis. The high- p_T trigger particle serves as the near-side jet axis. $p2n$ and $p3n$ indicate associated particles on the near-side and $p2a$ and $p3a$ indicate associated particles on the away-side. (Left panel) Simulated three-particle correlation for a deflected away-side jet in the PHENIX acceptance. (Right panel) Same as left panel but for a conical away-side jet.

2 Methodology and results:

2.1 Correlation Functions:

To study jet properties we use three-particle correlation functions built by combining a hadron in a specified high transverse momentum range ($2.5 < p_T < 4.0$ GeV/c) with two associated hadrons in an adjacent low transverse momentum range ($1.0 < p_T < 2.5$ GeV/c). The real triplets are obtained by combining all three particles from the same event. The mixed triplets are obtained by combining three particles from three different events. By transforming to the frame of reference in which the Z-axis is defined by the high p_T particle momentum vector, a two dimensional correlation function is obtained in θ^* , $\Delta\phi^*$ space where θ^* is the polar angle of one of the low p_T particles and $\Delta\phi^*$ is the difference of azimuthal angles of the two associated particles (see Fig. 1b). The three particle correlation functions can then be shown as polar plots in which θ^* is plotted along the radial axis and $\Delta\phi^*$ is plotted along the azimuthal axis (cf. Fig.1b).

2.2 Simulation Results:

Simulated three-particle correlation surfaces are shown in Figs. 1a and 1c for two distinct away-side jet scenarios; (i) a “deflected jet” in which the away-side jet axis is misaligned by 60° , and (ii) a “Cherenkov or conical jet” in

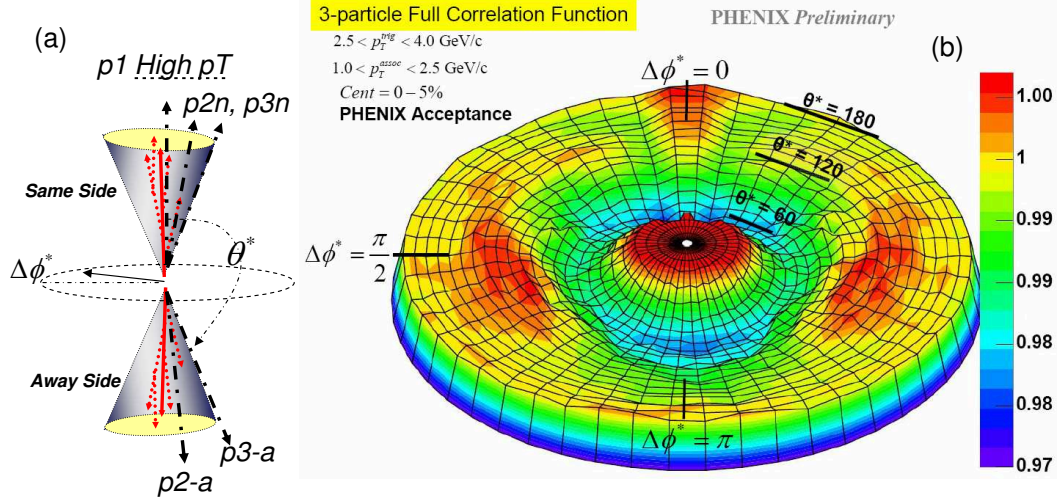


Fig. 2. (Color online)(a) Schematic illustration of coordinate system (same as Fig. 1b). (b) Full $\theta^*, \Delta\phi^*$ three particle correlation surface for charged hadrons detected in central (0-5%) Au+Au collisions within the PHENIX acceptance.

which the leading and away-side jet axes are aligned but fragmentation is confined to a very thin hollow cone with a half angle of 60° . It is interesting to note here that these correlation surfaces reflect the removal of harmonic contributions but *do* include 2+1 three-particle combinatoric contributions. That is, 2+1 correlations involving three particles, where two come from the jet/di-jet and the other from some other non-jet source. Nonetheless, both figures show rather clear distinguishing features for the two simulated scenarios considered.

2.3 Data Results:

The full three-particle correlation surface (no harmonic or 2+1 subtraction) obtained from data for the centrality selection 0-5% in Au+Au collisions is shown in Fig. 2b. A reminder of the coordinate frame used is given in Fig. 2a. In this polar ($\theta^*, \Delta\phi^*$) representation, one can clearly see the near-side jet correlations which are expected at the center of the correlation surface ($\theta^* = 0$). One can also see sizable correlations in $\Delta\phi^*$ for $\theta^* \sim 120^\circ$, albeit with acceptance losses especially in the region about ($\Delta\phi^* \sim 180^\circ$). Even without combinatoric background subtraction, it is apparent that the away-side jet shows a shape which is significantly different from that expected from a normal jet (ie. enhanced correlations for $\theta^* \sim 180^\circ$).

Figure 3 shows the resulting correlation surface (for centrality 20-40%) after removal of the harmonic contributions via a two-dimensional equivalent of the ZYAM procedure outlined in Ref. [3]. In this case, the away-side jet

V₂ subtracted Correlation Function

PHENIX Preliminary

$$2.5 < p_T^{\text{trig}} < 4.0 \text{ GeV}/c$$

$$1.0 < p_T^{\text{assoc}} < 2.5 \text{ GeV}/c$$

$$\text{Cent} = 20 - 40\%$$

PHENIX Acceptance

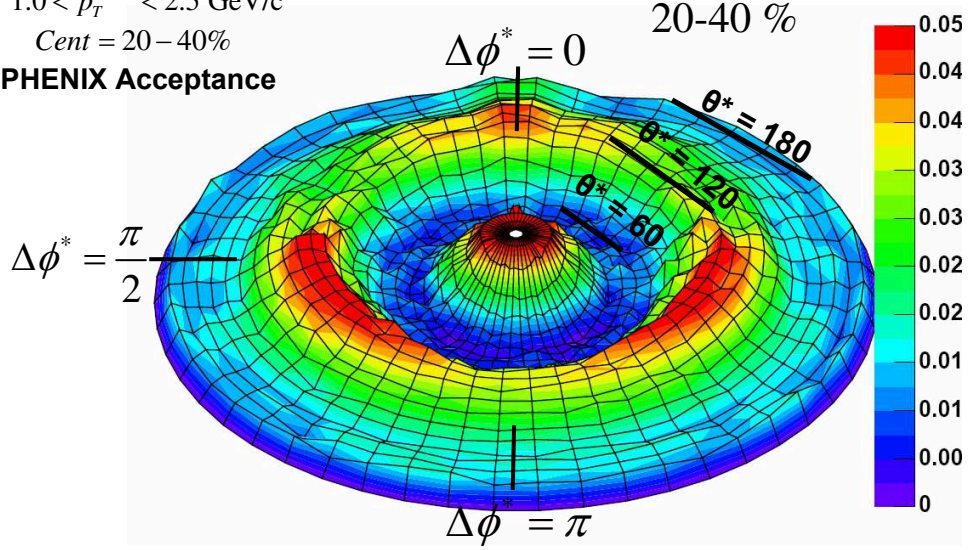


Fig. 3. (Color online) v_2 subtracted three particle correlation surface for charged hadrons detected in semi-central (20-40%) Au+Au collisions within the PHENIX acceptance.

correlations show a striking peak away from 180° for most of $\Delta\phi^*$ albeit with inefficiencies associated with the PHENIX acceptance. Figs. 2b and 3 provide compelling evidence for strong modification of the away-side jet.

The correlations shown in Figs. 2a and 3 are quite suggestive. However, a definitive and quantitative distinction of the mechanistic origin of the away-side jet modification requires the further step of removing the 2+1 combinatoric contributions from Figs. 2a and 3. Given the potential utility of these correlation measurements as additional constraints for the viscosity and sound speed of hot QCD matter [4], this step is being pursued vigorously. Suffice to say, systematic errors are currently being evaluated.

References

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